10. Impacts on flora and fauna

HOW TO USE THIS CHAPTER IN THE CONTEXT OF EA AND ROAD PLANNING

Stage in road planning (A)	EA activity (B)	Involvement in addition to EA team (C)
	Screening	
	Scoping	Proponent
Concept	Consultation	Key regulatory agency
Pre-feasibility	Determining baseline conditions	Other government agencies
Feasibility	Selection of preferred solution	NGOs
Engineering design	Assessment of alternative designs/methods	Research groups
Construction	Development of environmental management plan	Public/community organizations
Operation & maintenance	Effects and compliance monitoring	Advisory experts
	Evaluation	
	Reporting	

Shaded area = (A) Stages of EA covered in this chapter; (B) focus of this chapter; and (C) primary target readers.

KEY QUESTIONS ADDRESSED:

? How are road projects related to global concern for biodiversity?

? What are the common ecosystem types and their sensitivity to perturbations?

? What are the common direct and indirect impacts affecting these ecosystems?

? What methods can be used for ecosystem evaluation in situations where time and data are limited?

? How are indicators, VECs, and rapid appraisal applied to EA?

? What role can local expertise play in assessing potential impacts on flora and fauna?

10.1 IMPACTS AND SETTING

Previous chapters have examined the relationship between road development and various abiotic components of the environment, such as soil, water, and air. This chapter will look at the effects on some of the biotic inhabitants of the physical environment, namely flora and fauna.

The issue of impacts on flora and fauna is much broader than a concern for individual specimens, and any useful discussion in this area must be considered in the larger context of biodiversity conservation.

Biodiversity refers to the wealth of species and ecosystems in a given area and of genetic information within populations. It is of great importance at global and local levels. Areas of high biodiversity are prized as storehouses of genetic material which form the basis of untold numbers and quantities of foods, drugs, and other useful products. The more species there are, the greater the resource available for adaptation and use by humankind. Species which are pushed to extinction are gone forever; they are never again available for use.

At the ecosystem level, biodiversity provides flexibility for adaptation to changing conditions, such as those induced by human activity. Diverse systems are better able to adapt because their high degree of species redundancy allows for substitutions, thus facilitating the return to a state of equilibrium. Populations which are genetically highly diverse are better able to cope with induced reductions in population size and are therefore not as vulnerable to extinction as are less diverse populations.

Preservation of biodiversity is of global concern, but the causes of loss and their solutions are very often local in scale. Road development continues to be a major player in the overall reduction of biodiversity, and proper planning at the project level can go a long way in limiting the loss, while still serving the transport need.

10.1.1 Direct impacts

Habitat loss

The consumption of land, and the consequent loss of natural habitat, is inherent in road development. Where new roads intersect habitat, the area occupied by the road itself, borrow

pits, and quarries is subtracted from the total habitat area available to flora and fauna.

Habitat fragmentation

When a road cuts through an ecosystem, the sum of the two parts created by the cut is less than the value of the initial whole, even when the habitat loss is ignored. Ecosystems are characterized by complex, interdependent relations between component species and their physical environment, and the integrity of the ecosystem relies on the maintenance of those interactions. By slicing through habitat, roads affect an ecosystem's stability and health. Roads tend to fragment an area into weaker ecological sub-units, thus making the whole more vulnerable to invasions and degradation. Nevertheless, roads and natural ecosystems can co-exist if the relationship is built on careful planning.[1]

Corridor restrictions

Most animal species tend to follow established patterns in their daily and seasonal movements. The areas through which they travel on their way to and from feeding, breeding and birthing grounds, and between their seasonal ranges, are known as corridors. When a road intersects or blocks a wildlife corridor, the result is either cessation of use of the corridor because animals are reluctant to cross the road (see Box 10.1), an increase in mortality because of collisions with vehicles, or a delay in migration which may result in the weakening or disappearance of an entire generation of the population. Unfortunately, some animals are attracted to roads for various reasons, including protection from predators, good food supplies, better travel conditions, and so forth. This often leads to accidental death and poaching. On busy roads, the death rate for the local amphibian or other slow-moving animal populations can be as high as one in ten.

Aquatic habitat damage

Road development has perhaps its most serious effects on aquatic ecosystems. Erosion from poorly constructed and rehabilitated sites can lead to downstream siltation, ruining spawning beds for fish. Constriction of flows at water

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[1] This is demonstrated in the Government of Queensland's (Australia) Manual for Planning Roads in the Wet Tropics.

crossings can make the current too fast for some species. Alterations of flood cycles, tidal flows, and water levels can upset trophic dynamics by affecting the life cycle of plankton, and have corresponding effects on the rest of the food chain.

Rechanneling of waterways is often undertaken as part of road construction to avoid flooding and make crossing structures simpler. In the process, natural streambeds are dug up and useful obstructions, including large boulders, are removed. The same applies to shade trees on the banks. Frequently, the result is a straight, featureless channel, which may be an efficient evacuator of water, but has little in the way of the eddies, shaded areas, sheltering ledges, and turbulence essential to the health and existence of so many aquatic species (see Figure 10.1).

Roads may serve as barriers to movement of some aquatic species, especially where cul-

FIGURE 10.1
EFFECTS OF STREAM RECHANNELIZATION

Source: Simpson et al, 1982

verts are used. The issue of blockage or restriction of fish migration is extremely important and needs to be assessed for each relevant project. This is critical in areas of the world where streams are dry for part of the year, but during the monsoon season are active fish spawning waters, for example the Tonle Sap Lake watershed in Cambodia.

Interruption of biogeochemical cycle
The flow of nutrients and materials is a major determinant in ecosystem structure and function, and road development can easily disrupt

it through alteration of flows of surface and groundwater, removal of biomass, and relocation of topsoil. Also, human activity can be a major source of nutrients (sewage, animal dung, and eroded topsoil) which, provided they are allowed to get into the surface water, can raise turbidity and biological oxygen demand (BOD) of the water to the point where certain aquatic species simply cannot survive.

The potential impacts that alteration of the biogeochemical cycle may have on an ecosystem can be very roughly estimated once the nature of the alteration has been established, based on data on soil erodibility, soil fertility, and anticipated human activity, among other things. An understanding of the nutrient regime and energy flow of the affected ecosystem is essential.
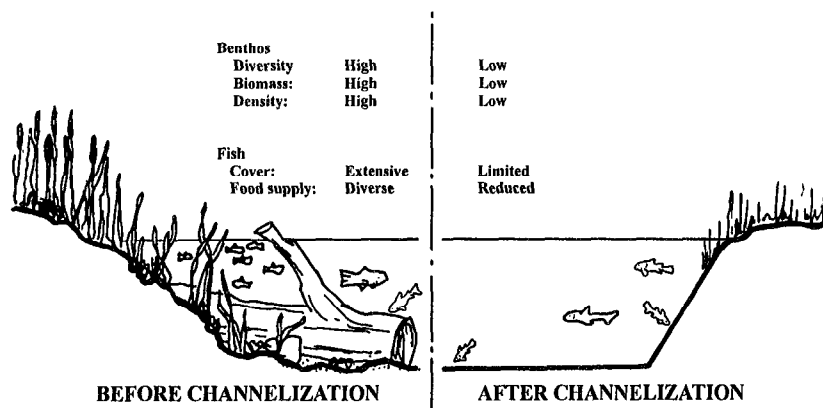
10.1.2 Indirect impacts

In many cases, indirect impacts are more damaging than direct ones, and their effects can be felt farther, sometimes several dozen kilometers, from the road (see also Section 6.1.2). Where the road provides access to areas which were previously relatively untouched by human activities, the environmental assessment should take account of these frequently far-reaching effects. Some indirect impacts encountered commonly are:

Accessibility
Roads increase contact between humans and the natural environment, which in most cases leads to ecosystem modification. Penetration of previously unmodified areas makes them available for a host of human activities of varying effect, from recreation, forest and mineral exploitation to colonization and urbanization. Upgrading of existing roads generally facilitates an increase in the number of people having access and is accompanied by an increase in the likelihood of impacts. A classic example of the accessibility impact is the widespread land degradation occurring in Brazilian Amazonia, which has been

induced in large part by road-building initiatives (see also Box 10.1).

Ecological disequilibrium

The importation of new plant and animal species along the right-of-way can upset the dynamic balance which exists in ecosystems. Native species face competition for resources from new arrivals, and predator-prey relationships can be altered, often to the detriment of the native species. Non-native species can gain a competitive advantage because of a lack of natural controls and become dominant. The result is usually a simplified ecosystem which is more vulnerable to further impacts.

In some cases, road development may actually alter the ecological equilibrium in a positive way by providing for the creation of new ecotones, which tend to be relatively biodiverse. This will only apply if the total area of the existing system is relatively large compared to the newly created ecotone. Also, the potentially positive effect will often be negated by the impacts discussed above.

Contamination of the biota

The presence of motor vehicles introduces the potential for contamination of the soil, air, and water adjacent to the road (see Figure 10.2), and in the case of surface water, well beyond the immediate surroundings. Chronic contamination can become a serious problem for animal species, especially those at the top of the food chain, because of bioaccumulation of pollutants.

Water contamination risks are discussed in Chapter 8, air pollution in Chapter 9, and soil

FIGURE 10.2
RISK OF CONTAMINATION FROM ACCIDENTS

Surface water Soil Water table Risks of pollution
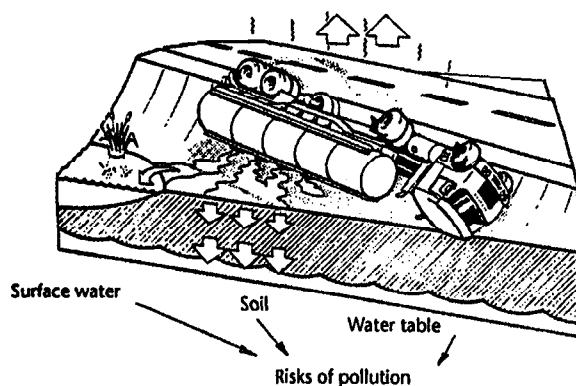
BOX 10.1
ACCESSIBILITY AND HABITAT FRAGMENTATION: A CASE STUDY

Mount Leuser National Park on Sumatra, Indonesia, has experienced serious encroachment and deforestation problems as a result of improved road access. The Kutacane to Blangkejeren road, which crosses the park, underwent improvements in the late 1970s, and the greater ease of access which resulted has attracted many new settlers, especially to the areas along the northern section of the road. Subsistence agriculture and illegal logging are producing a widening strip of deforested land along the road corridor. The road has become a barrier to many species of wildlife, and what was once one park is now essentially two.

Source: Republic of Indonesia, 1992.

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contamination in Chapter 7. Contamination issues associated with the operation and maintenance of roads are dealt with in Chapter 18.

Fires

Increases in human activity are often associated with more frequent incidents of fires, which can obviously have sudden, severe, and wide-ranging impacts.

Transmission of disease

Roads are effective vectors for the spread of diseases, which can have marked impacts on populations of plant and animal species. Carriers of diseases, both floral and faunal, can gain easy access to wilderness areas along new road corridors. Transportation of livestock and plant products, such as firewood, animal feed, and fruit, may also aid in spreading disease.

10.1.3 Ecosystem types and sensitivity

The biophysical environment is made up of a myriad of ecosystems of different types. Different ecosystem types experience impacts in different ways and display variable levels of resilience in the face of change, depending on factors such as biodiversity, climate, soil type, the similarity of adjacent ecosystems, and size. Some of the major ecosystem types are described briefly below:

Forest ecosystems are highly variable. The variability is determined mostly by climate and altitude. Tropical rain forests, at one end of the spectrum, are extremely biodi-

verse and productive, and are characterized by intense nutrient cycling. Boreal forests, at the other end, are subject to long winters, have relatively few species, and are neither especially dynamic nor particularly productive. The boreal forests exhibit slow nutrient cycling and represent massive stores of carbon. Deforestation is a frequent consequence of road development, and poses a threat to forest ecosystems worldwide.

Aquatic ecosystems, such as swamps, ponds, marshes, lakes, rivers, and streams, are habitats for important food sources and are characterized by a great wealth of flora and fauna, and high productivity. In general, these ecosystems are important because of their role in regulating the flow in waterways, in filtering water, and in serving as habitats for migratory birds and fish. These environments have regressed sharply over the last few decades and now merit significant protective measures.

Island ecosystems, depending on their size and distance from the mainland, tend not to be especially biodiverse,[2] and generally have a high incidence of endemic species. Interaction between island ecosystems and other terrestrial systems is very limited, or even non-existent, because of the expanse of open water between them. Forces tending to encourage species extinction have greater influence than do those encouraging colonization. The result is that the number of species is usually lower than it would be for a terrestrial ecosystem of the same area on a continental landmass. Island ecosystems are particularly vulnerable to changes that reduce habitat area and population size, because these populations have few choices once their habitat is degraded or lost, or their food sources have become extinct. They are also vulnerable to the introduction of non-native species, which normally do not have any local predators, and quickly get out of control.

Mountain and alpine ecosystems, because of their relatively high altitudes and extreme weather conditions, tend not to be especially rich in species (often highly endemic). They are characterized by steep slopes and are therefore prone to erosion when disturbed. Alpine vegetation, in particular, tends to be very fragile, and recovery of damaged areas can take decades.

Desert ecosystems are characterized by extreme temperature fluctuations, low annual rainfall, and high evaporation. As a result, their species diversity tends to be low (also endemic) and vegetation is usually sparse. What rainfall they do receive often comes in brief but very intense episodes; these have tremendous erosive potential, given that the soils are generally sparsely covered and low in organic matter. For climatic reasons, recovery or recolonization of damaged areas tend to be slow.

Coastal and riparian ecosystems are found at the boundaries between aquatic and terrestrial ecosystems. They tend to be dynamic, diverse, and productive. This applies more to wet climates than it does to dry ones. These systems usually exhibit a large number of species because they contain species from both bordering systems. Many species which inhabit these systems are living at the extremes of their ranges and are therefore especially vulnerable to changes in environmental conditions. Coastal ecosystems include mangrove swamps, salt marshes, dunes, beaches, and nearshore islands, while riparian zones are found at the intersection of terrestrial and freshwater systems such as swamps, rivers, lakes, and estuaries. Coastal and riparian ecosystems are important habitat areas for migrating waterfowl. Unfortunately, these systems are also preferred human settlement areas and are being lost rapidly to development.

Savannah ecosystems occur at a variety of latitudes and are characterized by semi-arid climatic conditions. Their vegetation consists mainly of widely spaced drought-resistant tree species, interspersed with herbaceous plants. Seasonal fluctuations in rainfall are very great, and erosion of disturbed soil can be a serious threat during the wet season.

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[2] Exceptions would be the larger Indonesian islands, Sri Lanka, Madagascar, and New Zealand.

Grassland ecosystems are dominated by herbaceous species and generally occur in areas experiencing relatively low rainfall, large amounts of sunshine, and plentiful winds. Grasslands are major carbon dioxide processors, and are thus important to global climate regulation. The sod layer operates as a highly effective protector of the soil against the elements, and its removal during road construction introduces an erosion risk.

Cave, limestone, and karst ecosystems often harbor rare species and display a high degree of endemism. Because of their relative inaccessibility, cave ecosystems have not been explored very extensively, and it is thought that they may contain many unknown species; this is especially true of water-filled cave systems. The systems provide habitat for highly specialized species which often have very limited distributions (some species have population sizes of less than one-hundred individuals, and are confined to single caves).[3] In some areas, cave bats are essential pollinators of economically important tree crops, while other species consume enormous quantities of pest insects. Cave ecosystems are particularly vulnerable to interruptions in groundwater flow, which can result from deep road cuts. Karst features are often the sources of limestone for cement production and are therefore constantly being depleted. Each time a karst formation or cave is mined or otherwise disturbed, biodiversity may be permanently reduced.

Tundra ecosystems occur at high latitudes and are characterized by permafrost (permanently frozen ground) and highly adapted, very fragile plant species. Although annual precipitation is low, the frozen subsurface means that surface water tends to accumulate. Road building in tundra areas invites a host of problems related to the melting of the permafrost and sinking of the roadbed. Most roads are only negotiable during the lengthy winters. As with de-

sert ecosystems, climatic extremes make recovery from disturbances very slow.

10.2 DETERMINING THE NATURE AND SCALE OF IMPACTS

Assessment of potential environmental impacts should take into account a) the extent of the proposed road development, b) the duration of the construction period, and c) the characteristics of the local natural environment through which the road will pass. The use of VECs as a starting point can be very useful in focusing this activity (see Section 3.2.3).

10.2.1 Extent of the project

The design specifications for the proposed road project can furnish details as to the width of the road and right-of-way, amount of cutting and filling, number and location of water crossings, type of water crossing structures, and degree of expected groundwater flow disturbance, as well as any expected raising or lowering of surface water levels. Generally, the larger the area affected, the more significant the impact.

10.2.2 Duration of the construction period

Intense, focused construction activities lasting for a short period of time generally have far less effect than those which may be less intense but are spread over long periods. As a general rule, construction periods which do not exceed the annual reproduction cycle of key organisms (a fish species, for example) usually have less impact than projects which stretch over generations.

10.2.3 Evaluation of the affected systems

An evaluation of the ecosystem or ecosystems to be intersected by a road should have two objectives: a) to take stock of the existing organisms in relation to how their function might be changed by a road, and b) to determine the area's sensitivity to the magnitude and types of change that are expected. Whenever possible, these evaluations should be completed in the context of the local watershed or drainage basin in which the project is to be located.

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[3] See Culver, 1986.

Characterization

The descriptive component of the evaluation should comprise[4]

- an inventory of biotic and abiotic resources, as well as their geographic distribution. This can be aided by working with local natural scientists and scientific institutions,[5] and by making use of computer databases and biological inventories that may be available from national and international agencies;

- an estimation of productivity (soil fertility for terrestrial ecosystems, density for aquatic ones);

- a description of species associations, relationships, keystone species, biodiversity, and the food chain;

- a listing of rare or vulnerable species;

- an estimation of ecological significance, which implies importance in the workings of nature on a grander scale—an ecologically significant species, population, or ecosystem may not in itself be rare or extremely sensitive, but its impairment or removal could have effects on other species, populations, or ecosystems; and

- a description of the resource needs of species—biogeochemical cycling and the food chain should be considered.

Sensitivity

Once the extent of the project is known, and the characterization of the affected area's VECs[6] is complete, the sensitivity of the ecosystem to the proposed changes (or, conversely, its resilience) can be evaluated by considering

- environmental variables which are likely to experience changes of a magnitude greater than that of natural variations;

- previous experience with change (evidence of soil erosion, invasion by non-native species, ecosystem simplification); and

- likely effects on species which are instrumental in the formation and maintenance of habitat, offer crucial links in the food chain, are particularly vulnerable (i.e. rare, or dependent on a single resource), whose corridors are intersected by the proposed road, and whose resource use will be affected by the development.

10.2.4 Use of indicator species or groups

Given the variety of plant and animal species present in most ecosystems, as well as the complexity of their relationships, it is almost impossible to evaluate susceptibility to damage from a road development without extensive data gathering. The small species are particularly difficult to itemize. A practical solution is to use indicators.[7] Indicators are physical, chemical, or biological attributes which provide some indication of the health of an ecological system (see Appendix 3). Rather than identify and study every component of an ecosystem or VEC to determine ecosystem function and health quantitatively, the presence, absence, or state of chosen indicators is used to extrapolate a qualitative impression. Indicators fall into four groups:

i) *response indicators*, which provide evidence of the biological condition at the organism, population, community, ecosystem, or landscape level, e.g. biodiversity;

ii) *exposure indicators*, which indicate the presence of a stressor, e.g. algal blooms;

iii) *habitat indicators*, which are used to characterize conditions necessary to support an organism, population, community, or ecosystem; and

iv) *stressor indicators*, which are natural processes, environmental hazards, or management actions that produce changes in exposure and habitat, e.g. water quality.

Proper evaluation of the state of an entire ecosystem relies on the monitoring of indicators from each group. Indicators should also be selected to represent several levels of organization within an ecosystem.

Indicators are of limited use in predicting impacts directly, but can be used to describe

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[4] Such detailed information is required only for full EAs. For IEEs, secondary data would be the primary source.

[5] Most freqently this is not the case, and outside technical expertise is needed. In these situations, the work should be turned into a capacity-building activity, with local experts working side-by-side with outside specialists, undertaking studies, preparing field guides, etc.

[6] The VEC concept is effective in focussing the study area more efficiently; the concept is described in Chapters 3 and 4, and should be initiated during the EA scoping stage.

[7] This is a complex topic and users are urged to read other sources such as Knapp et al. (1991), Victor, Kay and Ruitenbeek (1991), and Kelly and Harwell (1990).

conditions as well as show trends and environmental response; they can therefore contribute to baseline studies and monitoring.

10.2.5 Rapid appraisal

Rapid appraisal is a useful tool for assessments in which the complexity of the environment is so great, or the time available so limited, that a full-scale study is not feasible. Rapid appraisal allows a great deal of varied information to be brought together and synthesized in a relatively short period of time. The method blends modern scientific with traditional knowledge instead of relying soley on quantitative research and empirical results.

Beginning with baseline studies, experts in fields such as ecology, geology, and hydrology, as well as traditional users of the local natural environment, who may have extremely valuable first-hand information and knowledge of their surroundings, provide input about species inventory and ecosystem structure, as well as their function and sensitivity. Surveys, interviews, and meetings of varying degrees of formality are common appraisal components. By using VECs, the appraisal can be even more focused.

The wealth of information thus amassed is considered in the context of the road design specifications and the initial impact appraisal is produced. In the final stage, the appraisal is made available for comment from all contributors and adjusted if necessary. The result is a relatively quick and accurate assessment based on multidisciplinary consensus.

10.2.6 Modeling

While ecological systems are not as well understood as those described by the physical sciences, modeling can nevertheless have applications in assessment of potential impacts on them. Modeling of complex ecosystems may involve combining several models from different disciplines. Thus, the impact resulting from the introduction of a pollutant to groundwater on a certain fish species might be assessed using hydrological models to simulate the delivery of the pollutant to the fish, and a biological model to determine the long-term consequences of the resulting mortality on the fish population.

Computers are often used in environmental modeling, and the development of new computer models is ongoing. Some computer modeling applications which may be relevant to the assessment of ecological impacts are discussed in Chapter 8 (hydrological), Chapter 9 (atmospheric), and Chapter 16 (noise).

10.2.7 Useful sources of information

Every assessment should make use of the various documents available, including topographic, pedological (soil), vegetation, and climate maps; scientific and technical studies; research reports; aerial or satellite photographs (Box 10.2); biological inventories and computer databases. This information may be available from research centers, specialized institutions, universities, government departments, and other project offices[8].

Geographic information systems may also be very useful in visualizing the spatial relationships between ecosystems, the distributions of their component species, and a proposed road alignment. They may also have applications in monitoring the effects of road development (Box 10.2).

10.3 REMEDIAL MEASURES

10.3.1 Prevention

When planning new roads or changes in width or alignment, sensitive natural environments should be identified early in the planning process so that alternate routes and designs may be considered. Wherever possible, road developments should be located more than one kilometer away from sensitive areas to avoid severe impacts on flora and fauna. Water crossings should be minimized, and buffer zones of undisturbed vegetation should be left between roads and watercourses. Groundwater recharge areas should be avoided, and major roads should not be constructed through national parks or other protected areas. Advantage should be taken of opportunities to twin new road corridors with previously established transport rights-of-way, such as railway lines.

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[8] A few of the many basic sources are: the World Conservation Monitoring Center Web Site and the GEMS database of the World Health Organization.

10.3.2 Mitigation

Re-engineering road cross-section designs

Road cross-section can be modified to reduce the impact on the environment, for example, by using narrower widths, lower vertical alignments, smaller cuts and fills, flatter side slopes, and less clearing of existing vegetation. Narrower rights-of-way and lower vertical alignment may make crossing easier for animals that find roads a physical or psychological barrier. Also, providing longer sight lines for drivers can reduce collisions with animals by allowing more reaction time.

Planting

Planting in road rights-of-way and adjacent areas can help to support local flora and fauna. In some cases, planting may provide additional habitats and migration routes for local animals, while also guarding against erosion. Border plant species may need to be chosen for resistance to wind or fire in some areas. Planting should be done wherever possible with native species, which are likely to require little maintenance and may prove beneficial in maintaining ecosystem integrity.[9] In cases where non-native species are deemed essential, careful monitoring should be planned, to ensure that they do not compete too successfully with native species and spread uncontrollably.

Animal crossings

Animal crossings can be used to assist the migration of animals. At important crossing points, animal tunnels or bridges have sometimes been used to reduce collision rates, especially for protected or endangered species. Tunnels are sometimes combined with culverts or other hydraulic structures (Figure 10.3). These measures are expensive and used only at a few locations where they are both justified (by the importance of the animal population and the crossing route) and affordable (relative to the cost of the project and the funds available).

BOX 10.2
MONITORING LONG-TERM CHANGES IN A ROAD'S ENVIRONMENT

In Ethiopia, aerial photographs and satellite images were used to monitor and analyze changes in the environment of a highway between 1980 and 1993. The road under study crossed an area previously untouched by modern development and quite isolated from the outside world. It was anticipated that population and land use changes would begin immediately after construction of the new road, while traffic flows would increase only gradually.

In the study period, the population of the study area increased from 92,000 to 211,000 people, in part for reasons not related to the road. The number and size of smaller villages increased, and major villages doubled in number. Past aerial photographs and more recent Landsat and Spot data were used to establish four situation maps, and the data were stored in a geographic information system (GIS).

A comparison of the land use maps over this period shows the growth of human settlements and land under moderate and intensive cultivation. A large bamboo forest has been cleared, and the remaining forest is threatened. While the area has a high potential for agricultural development, there is a need to take measures to prevent erosion, loss of soil fertility, and further reduction in forest areas.

Source: Asplan Viak, 1994.

In forested areas, especially tropical ones, reducing the width of vegetation clearance in selected areas may allow trees to touch over the roadway, providing a means of crossing for canopy dwellers.

Fencing

Fencing or plant barriers can reduce the risk of collisions between animals and vehicles. In some cases, semi-permeable fencing is used, which excludes species that are more likely to be involved in collisions while letting less problematic species through. Fences may interfere with the migratory patterns of animals, or may simply shift the points where migratory patterns conflict with traffic patterns along the route. Fencing may also, in some cases, interfere in predator-prey relationships, allowing predators to gain significant advantage because prey escape routes are restricted.

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[9] Harper-Lore (1996) discusses successful experiences with this approach in the United States.

FIGURE 10.3
WILDLIFE UNDERPASS AND HYDRAULIC STRUCTURE

◄— 2m —►   ◄— 3m —►
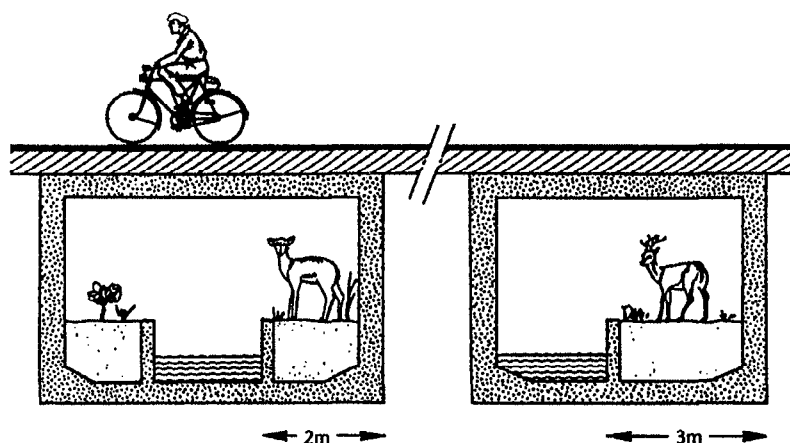
Water crossings

Aquatic ecosystems are particularly sensitive to road development, and there are a number of ways in which the impacts can be lessened. Standing water can be bridged instead of filled. Stream rechanneling should be avoided as much as possible, but where it must be done, efforts should be made to recreate lost channel

diversity. Careful attention should be paid to erosion control techniques near watercourses (see Chapters 7 and 8). Culverted crossings should be designed with the needs of migratory aquatic species in mind. Baffles might be installed to slow the flow enough to allow fish and others to swim against the current, and culvert bottoms should be set below the level of the stream bed. Pre-development streambed gradients should be maintained wherever possible.

Traffic control measures

Reduction of the speed limit may reduce the rate of collisions between vehicles and animals. Some jurisdictions apply lower speed limits, particularly at night and in areas of frequent animal crossings. Signs warning motorists of the presence of animals in places where animal corridors cross the road may also help to reduce collisions. Roadside reflectors may be used to scare animals away from the roadway when vehicles approach at night. Some of these options are compared in Table 10.1.

TABLE 10.1
INDICATIVE COMPARISON OF MITIGATIVE MEASURES FOR PROTECTING FLORA AND FAUNA

Measure	*Effectiveness*	*Compared costs*
Vegetative protection fence	Medium protection, excellent integration into the landscape	Low cost, requires maintenance
Artificial fence	Good protection of animals and drivers, but can inhibit animal movements	Comparable to vegetation fence
Animal overpass	Very effective where warranted	Expensive; same as normal overpass
Animal underpass	Less effective than overpasses for most species, but more common for cost reasons	Same as a culvert
Speed reducing devices	Effective if well enforced	Relatively low cost
Developing of forest borders, planting	Complements the above devices, preferably using local species	Low cost for relatively good results

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BOX 10.3
MITIGATIVE MEASURES FOR ROADS WHICH TRAVERSE NATIONAL PARKS

Most national parks are designated as such because of their ecological significance or recreational value, and are set aside for their protection and preservation. **It is always preferable to avoid the construction of a road for through traffic across a national park or other protected area.** In cases where major roads must cross parks and conflicts between road users and the natural environment are anticipated, various mitigative measures which might not ordinarily be justified may be implemented. These could include

- enactment and enforcement of laws prohibiting hunting, transport of hazardous substances, and removal of plant materials from the park;
- inspection of the contents of vehicles entering the park, in order to discourage importation of potentially hazardous cargoes, such as livestock, when there is reason to believe that disease spread may be an issue; and inspection of vehicles leaving the park, for poached animals and plant materials;
- educational measures aimed at informing the travelling public about the reasons for not feeding wildlife, removing plants, littering, etc., and to instill a general appreciation of the desirability of conservation;
- application of the standard mitigative measures, as discussed in Section 10.3.2, to a greater extent or with greater frequency than in less sensitive situations;
- implementation of traffic control measures such as volume restrictions, lower speed limits (especially at night), and forbidding vehicles to stop while crossing the park;
- provision of rest areas with garbage cans and toilet facilities to discourage indiscriminate stopping along the roadside and littering; and
- use of design features such as deep ditches, narrow shoulders, and barriers to discourage roadside stops and removal of plant materials.

In sensitive areas, such as national parks, additional measures may be needed (Box 10.3).

10.3.3 Compensation

One common compensatory measure is to replace damaged or lost biotopes with others of equal or similar characteristics and ecological significance. Environments damaged by a road project can be restored, and nearby biotopes of the same significance can be protected as parks or reserves. This is only feasible when the affected area is not unique.

Environmental resource 'banking' is a term used to describe the preservation, restoration, enhancement, or even creation of valuable habitat areas to compensate for unavoidable loss of similar resources elsewhere. Reppert (1992) describes the application of this technique to wetland areas in the United States.

10.4 MINIMIZING IMPACTS ON FLORA AND FAUNA: AN ACTION CHECKLIST

The more important steps in the EA process relative to the incorporation of concerns about conserving biodiversity in the road development process are highlighted below.

Collect relevant data
Baseline data should identify areas of ecological interest within the study area. The identification criteria, adapted to the scope of the investigations, will be those commonly used in ecology: biodiversity, rarity and vulnerability of species, wildlife corridors, and so forth.

Make informed alignment choices
Identify potential impacts of road development proposals and carry out a comparative analysis of the various route alternatives in terms of their respective consequences for the natural environment (for details on the analysis of alternatives, see Chapters 3 and 4). Choose routes that avoid sensitive areas and VECs.

Select preferred design
Select the design that interferes the least with wildlife movements and creates the least disturbance to nutrient cycling, especially as related to water movement.

Prepare mitigation plan
Mitigation plans should be suited to the scope of the project, the extent of environmental impacts, and the means available. All measures

proposed should balance cost with effectiveness.

vention of erosion and contamination during construction.

Environmental specifications in contract documents

Environmental specifications for contractors should cover management of work forces (control of poaching and firewood collection), machinery (speed, noise, and traffic), and pre-

Legislation and regulations

Laws pertaining to plant and animal species, protected areas, hunting, fishing, and forestry should be used where available and developed as a more permanent means of impact minimization.

10.5 REFERENCES AND BIBLIOGRAPHY

American Association of State Highway and Transportation Officials. 1976. *A Design Guide for Wildlife Protection and Conservation for Transportation Facilities*. Washington, DC.

Aramburu, P Y. and R. Escribano. 1987. "Ecological Impacts: The Practice of Estimating Impact" (in Spanish). Madrid: Fondacion Conde del Valle de Salazar (ETSIM).

Beanlands, G.E. and P.N. Duinker. 1983. *An Ecological Framework for Environmental Impact Assessment in Canada*. Halifax, Canada: Institute for Resource and Environmental Studies.

Cofiroute. 1990. "Living Together in Sologne." Film. Paris.

Culver, David C. 1986. "Cave Faunas", in *Conservation Biology: The Science of Scarcity and Diversity*, Michael E. Soulé, ed. Summerland, MA: Sinamer Associates, Inc.

Federal Highway Administration. 1986. *Highways and Wetlands: Compensating Wetland Losses*. Washington, DC: US Department of Transportation.

France, Ministry of Infrastructure. 1993. "Road Crossings for Wild Animals" (in French). Bagneux, France: Roads and Highways Technical Studies Department (SETRA).

France, Ministry of Infrastructure. 1987. "Ecological Observations on the Lower Valley of the Doller, Listings and Perspectives" (in French). Mulhouse, France: Roads and Highways Technical Studies Department (SETRA), Eastern Technology Research & Development Center.

France, Ministry of Infrastructure. 1987. "Road Management for Wildlife." Information Note (in French). Bagneux, France: Roads and Highways Technical Studies Department (SETRA).

France, Ministry of Infrastructure. 1986. "Protection of Fauna and Road Traffic" (in French). Bagneux, France: Roads and Highways Technical Studies Department (SETRA).

Gonzales Bernaldez, F. 1981. "Ecology and Landscape" (in Spanish). Madrid: Blume.

GHD Ltd (Guttridge, Haskins & Davey Ltd). 1997. *Roads in Wet Tropics: Planning Design Construction Maintenance and Operation: Best Practice Manual (final draft)*, 4870. Cairns, Queensland Australia: Department of Main Roads.

Harper-Lore, B.L. 1996. "Using Native Plants as Problem-Solvers". *Environmental Management*. 20:6:827-830.

Holdgate, Martin. 1996. "The Ecological Significance of Biodiversity". *Ambio*. 25:6:409-416.

Kelly, John R. and M.A. Harwell. 1991. "Indicators of Ecosystem Recovery". *Environmental Management*. 14(5):527-545

Knapp, C.M. et al. 1991. *The Indicator Development Strategy for the Environmental Monitoring and Assessment Program*. Corvallis, OR: US Environmental Protection Agency.

Kottelat, M. and T. Whitten. 1996. *Freshwater biodiversity in Asia*. Washington, DC: The World Bank.

Krawetz, Natalia. 1991. *Social Impact Assessment; An Introductory Handbook*. Halifax, Canada: EMDI Project Publication, Dalhousie University.

McNeely, J.A. et al. 1990. *Conserving the World's Biological Diversity*. Gland (Switzerland) and Washington, DC: World Bank, World Resources Institute, IUCN, Conservation International, and WWG.

Mahar, D.J. 1989. *Government Policies and Deforestation in Brazil's Amazon Region*. Washington, DC: World Bank.

Misra, P.N. and P.D. Agravals. 1982. *Ecology and Roads in U.P. Hinalays Indian Highways*. New Delhi, India.

New England Research Inc. 1978. *Highways and Ecology: Impact Assessment and Mitigation*. Washington, DC: US Department of Transportation, Federal Highway administration.

Reppert, R. 1992. *Wetlands Mitigation Banking Concepts*. Institute for Water Resources, IWR Report No. 92-WMB-1. Washington, DC: US Army Corps of Engineers.

Republic of Indonesia, Ministry of State for Population and Environment. 1992. *Indonesian Country Study on Biological Diversity*. Jakarta.

Secrett, C. and V.C. Hodges. 1986. *Motorway Madness: Roads and Their Impact on the Natural Environment*. London: Friends of the Earth.

Simpson, et al. 1982. *Manual of Stream Channelization Impacts on Fish and Wildlife*. US Department of Interior.

Urban Wildlife Research Center. 1982. *Wildlife Considerations in Planning and Managing Highway Corridors: User's Manual*. Washington, DC: US Department of Transportation, Federal Highway Administration.

Victor, Peter, J.J. Kay and H.J. Ruitenbeek. 1991. *Indicators of Ecological Sustainable Development*. Canadian Environmental Advisory Council. Ottawa, Canada: Ministry of Supply and Services.

Ward, Janet C. 1990. *Environmental Indicators for State of the Environment Reporting*. Canterbury, New Zealand: Center for Resource Management.

World Bank. 1992. *Guidelines for Monitoring and Evaluation of GEF Biodiversity Projects*. Washington, DC: World Bank.